DEPARTMENT OF CIVIL ENGINEERING

Course Book for
M. Tech. in Geotechnical
Engineering

For

Academic Year 2019-2020

Visvesvaraya National Institute of Technology,

Nagpur-440010 (M.S.)

Institute Vision Statement

To contribute effectively to the National and International endeavour of producing quality human resource of world class standard by developing a sustainable technical education system to meet the changing technological needs of the Country and the World incorporating relevant social concerns and to build an environment to create and propagate innovative technologies for the economic development of the Nation.

Institute Mission Statement

The mission of VNIT is to achieve high standards of excellence in generating and propagating knowledge in engineering and allied disciplines. VNIT is committed to providing an education that combines rigorous academics with joy of discovery. The Institute encourages its community to engage in a dialogue with society to be able to effectively contribute for the betterment of humankind.

Department Vision Statement

To contribute effectively to the National Endeavour of producing a quality human resource of world-class standard in civil engineering by developing a sustainable technical education system to meet the changing technological needs of the Country incorporating relevant of social concerns and to build an environment to create and propagate innovative technologies for the economic development of Nation.

Department Mission Statement

The Mission of the undergraduate civil engineering program is to develop students into capable civil engineering graduates by imparting appropriate high-quality education in Civil Engineering so that they could be readily adapted by the service sector to meet the challenges faced by the Nation. The program strives for excellence in engineering education and profession. It also aims to promote all-round development of the personality of students by suitably involving them in Co-curricular and extra-curricular activities.

Our mission is the provision of human services in a sustainable way, balancing society’s need for long-term infrastructure and environmental health. The department believes that it is imperative that human infrastructure and the natural environment be viewed in a synergistic way in order to fulfill this mission. We can achieve this mission through engineering and science education.

Brief about Civil Engineering Department:

Civil Engineering Department is the oldest department in this institute right from the establishment of Government College of Engineering in Nagpur 1956. The department offers the undergraduate course of B.Tech in Civil Engineering and Four Postgraduate Courses of M.Tech as given below.

List of Faculty Members

Name of Faculty Member	Designation	Qualifications	Areas of specialization
Mhaisalkar V. A.	Professor	B.E., M.Tech, Ph.D	Environmental Engineering
Gupta R.	Professor	B. E., M.Tech, Ph.D.	Environmental Engineering
Katpatal Y. B.	Professor	B.Sc., M.Tech, MBA, Ph.D	Remote Sensing & GIS
Tembhurkar A. R.	Professor	B.E., M.Tech, Ph.D	Environmental Engineering
Ghare A. D.	Professor	B.E., M.Tech, Ph.D	Hydraulics Engineering
Lataye.D. H.	Professor	B.E., M.Tech, Ph.D	Environmental Engineering
Landge V. S.	Professor	B. E., M.E., Ph.D	Transportation Engineering
Ralegaonkar R.V	Professor	B.E., M.E., Ph.D	Construction Technology & Management
Latkar M. V.	Associate Professor	B.Sc., M.Sc., Ph.D	Environmental Biochemistry
Mandal A.	Associate Professor	B. E., M.E., Ph.D	Geotechnical Engineering
Vasudeo A. D.	Associate Professor	B.E., M.Tech, Ph.D	Water Resources Engineering
Patel A.	Assistant Professor	B.E., M.Tech, Ph.D	Geotechnical Engineering
Dongre S. R.	Assistant Professor	B.E., M.Tech, Ph.D	Environmental Engg.
Wanjari S. P.	Assistant Professor	B.E., M.Tech, Ph.D	Construction Technology & Management
Tawalare A. G	Assistant Professor	B.E., M.Tech,Ph.D.	Structural Engg.
Mirajkar A. B.	Assistant Professor	B. E., M.E., Ph.D	Water Resources Engineering
Madurwar M. V.	Assistant Professor	B. E., M.E., Ph.D	Construction Technology & Management
Adhikary S.	Assistant Professor	B.E., M.Tech, Ph.D	Soil Dynamics
Padade A. H.	Assistant Professor	B.E., M.Tech, Ph.D	Geotechnical Engineering
Srinivasan V.	Assistant Professor	B.Tech, M.Tech, Ph.D	Geotechnical Engineering
Karthik B.	Assistant Professor	B.E., M.Tech, Ph.D	Environmental Engineering
Sita Rami Reddy D.	Assistant Professor	B.Tech., M.Tech, Ph.D	Transportation Engineering
Raghu Ram K.	Assistant Professor	B.Tech, M.Tech, Ph.D	Transportation Engineering
Ankit Kathuria	Assistant Professor	B.Tech, M.Plan, Ph.D	Transportation Engineering
Udit Jain	Assistant Professor	B.Tech, M.Plan, Ph.D	Transportation Engineering

Program	Description
UG in Civil Engineering	Started with 60 seats in 1956 Intake increased to 71 in 2008 Intake increase to 82 in 2009 Intake increase to 92 in 2010 Intake increase to 120 in 2019
PG in Civil Engineering Department	
1. Environmental Engineering	Started in 1966 (32 seats)
2. Water Resources Engineering	Started in 2005 (20 seats)
3. Construction Technology& Mgt	Started in 2010 (20 seats)
4. Transportation Engineering	Started in 2012 (20 seats)
5. Geotechnical Engineering	Started in 2019 (20 seats)

Credit System at VNIT:

Education at the Institute is organized around the semester-based credit system of study. The prominent features of the credit system are a process of continuous evaluation of a student's performance / progress and flexibility to allow a student to progress at an optimum pace suited to his/her ability or convenience, subject to fulfilling minimum requirements for continuation. A student's performance/progress is measured by the number of credits he/she has earned, i.e. completed satisfactorily. Based on the course credits and grades obtained by the student, grade point average is calculated. A minimum number of credits and a minimum grade point average must be acquired by a student in order to qualify for the degree.

Course credits assignment:

TABLE 1. CREDIT REQUIREMENTS FOR POST GRADUTE STUDIES

Postgraduate Core (PC)		**Postgraduate Elective (PE)**	
Category	Credit	Category	Credit
Departmental Core (DC)	39	Departmental Electives (DE)	13 - 15
Total	39	Total	13 - 15
Grand Total DC + DE			52

Each course, except a few special courses, has certain number of credits assigned to it depending on lecture, tutorial and laboratory contact hours in a week.

For Lectures and Tutorials: One lecture hour per week per semester is assigned one credit and

For Practical/ Laboratory/ Studio: One hour per week per semester is assigned half credit.

Example: Course XXXXXX with (3-0-2) as (L-T-P) structure, i.e. 3 hr Lectures + 0 hr Tutorial + 2 hr Practical per week, will have (3x1 + 0x1 + 2x0.5 =) 4 credits.

Grading System:

The grading reflects a student's own proficiency in the course. While relative standing of the student is clearly indicated by his/her grades, the process of awarding grades is based on fitting performance of the class to some statistical distribution. The course coordinator and associated faculty members for a course formulate appropriate procedure to award grades. These grades are reflective of the student's performance vis-à-vis instructor's expectation. If a student is declared pass in a subject, then he/she gets the credits associated with that subject.

Depending on marks scored in a subject, a student is given a Grade. Each grade has got certain grade points as follows:

Grade	Grade points	Description
AA	10	Outstanding
AB	9	Excellent
BB	8	Very good
BC	7	Good
CC	6	Average
CD	5	Below average
DD	4	Marginal (Pass Grade)
FF	0	Poor (Fail) /Unsatisfactory / Absence from end-sem exam
NP	-	Audit pass
NF	-	Audit fail
SS	-	Satisfactory performance in zero credit core course
ZZ	-	Unsatisfactory performance in zero credit core course
W	-	Insufficient attendance

Performance Evaluation

The performance of a student is evaluated in terms of two indices, viz, the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester and Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time. CGPA is rounded up to second decimal.

The Earned Credits (ECR) are defined as the sum of course credits for courses in which students have been awarded grades between AA to DD. Grades obtained in the audit courses are not counted for computation of grade point average.

Earned Grade Points in a semester (EGP) = **Σ** (Course credits x Grade point) for courses in which AA- DD grade has been obtained

SGPA = EGP / Σ (Course credits) for courses registered in a semester in which AA- FF grades are awarded

CGPA= EGP / Σ(Course credits) for courses passed in all completed semesters in which AA- DD grades are awarded

Overall Credits Requirement for Award of Degree

SN	Category of Course	Symbol	Credit Requirement			
			B. Tech. (4-Year)	B. Arch. (5 Year)	M. Tech. (2 Year)	M. Sc. (2 Year)
	Program Core					
1	Basic Sciences (BS)	BS	18	04	-	-
2	Engineering Arts & Sciences (ES)	ES	20	18	-	-
3	Humanities	HU/ HM*	05	06	-	-
4	Departmental core	DC	79-82	168	33-39	54-57
	Program Elective					
3	Departmental Elective	DE	33-48	17-23	13-19	06-09
4	Humanities & Management	HM	0-6	0-3	-	-
5	Open Course	OC	0-6	0-3	-	-
Total requirement :BS + ES + DC+ DE + HM + OC =			**170**	**219**	**52**	**63**
Minimum Cumulative Grade Point Average required for the award of degree			**4.00**	**4.00**	**6.00**	**4.00**

Attendance Rules

1. All students must attend every class and 100% attendance is expected from the students. However, in consideration of the constraints/ unavoidable circumstances, the attendance can be relaxed by course coordinator only to the extent of not more than 25%. Every student must attend minimum of 75% of the classes actually held for that course.
2. A student with less than 75% attendance in a course during the semester, will be awarded W grade. Such a student will not be eligible to appear for the end semester and re-examination of that course. Even if such a student happens to appear for these examinations, then, answer books of such students will not be evaluated.
3. A student with W grade is not eligible to appear for end semester examination, reexamination & summer term.

Program Outcomes

1. The graduates are expected to have an ability to apply knowledge of mathematics, science and engineering while doing the design and analysis of various geotechnical structures and its components.

2. The graduates are expected to have the ability to predict and adopt innovative solutions for complex and challenging geotechnical problems. In addition, they should be able to propose optimal and economical solutions to the geotechnical problems in a best possible practical manner.

3. The graduates are expected to have capability to take research projects in the field of geotechnical and geoenvironment engineering and also be able to develop modern solution using advanced technological concepts.

4. The graduates are expected to identify and use modern tools /equipments for analysis and design of components of geotechnical structures.

5. The graduates are expected to participate in collaborative and multidisciplinary work in order to contribute to the overall development of the society.

6. The graduates are expected to participate in group projects and have ability to manage project competently through efficient and optimal use of resources.

7. The graduates are expected to communicate technical details effectively through oral presentation and written documents.

8. The graduates are expected to engage themselves in life-long learning and keep on updating themselves with technological advances.

9. The graduates will understand and follow ethical practices in geotechnical engineering.

10. The graduates are expected to critically examine, judge and decide independently the outcome of works carried out in their careers.

Scheme for M. Tech. Geotechnical Engineering

First Semester

Course Code	Course Name	Type DC/DE	Structure	Credits
CEL 520	Advanced Soil Mechanics	DC	3-0-0	3
CEL 423	Introduction to Soil Dynamics	DC	3-0-0	3
CEL 521	Applied Soil Engineering	DC	3-0-0	3
CEL 442	Geotechnical Investigations for construction projects	DC	3-0-0	3
CEL 522	Geomechanics	DC	3-0-0	3
CEP 504	Geotechnical Engineering Laboratory Work	DC	0-0-2	1
Core Credits = 16				
Elective (Any One)				
CEL 526	Ground Water Hydrology	DE	3-0-0	3
CEL 417	Disaster Management	DE	3-0-0	3
CEL 508	Environmental Geotechniques	DE	3-0-0	3
MAL 401	Finite Difference Methods for Differential Equations	DE	3-0-0	3
Elective Credits = 03				
5 DC + 1 DE = 19 Credits				

Second Semester

Course Code	Course Name	Type DC/DE	Structure	Credits
CEL 523	Advanced Foundation Engineering	DC	3-0-0	3
CEL 575	Ground Improvement Techniques	DC	3-0-0	3
CEL 581	Design of Underground structures	DC	3-0-0	3
CEP 505	Geotechnical Engineering Field Work	DC	0-0-2	1
CEP 506	Geotechnical System Design	DC	0-0-2	1
Core Credits = 11				
Elective (Any Two)				
AML 548	Soil Structure Interaction	DE	3-0-0	3
AML 549	Finite Element Method	DE	3-0-0	3
MNL 525	Blasting Technology in Excavations	DE	3-0-0	3
MNP 525	Blasting Technology in Excavations – Practical *	DE	0-0-2	1
CEL 441	Geotechnical Aspects for design of machine Foundation	DE	3-1-0	4
CEL 510	Environmental Management	DE	3-0-0	3
CEL 525	Earthen Dam	DE	3-1-0	4
CEL 524	Geosynthetics	DE	3-0-0	3
CEL 529	Engineering Seismology and Site Characterization	DE	3-0-0	3
CEL 532	Design of Experiments	DE	3-0-0	3
Elective Credits = 07 to 08				
3 DC + 2 DE = 18 to 19 Credits				

Third Semester

Course Code	Course Name	Type DC/DE	Structure	Credits
CED 501	Project Phase-I	DC	-	3
Core Credits = 03				
Elective (Any One)				
CEL 409	Quality and Safety in Construction	DE	3-0-0	3
CEL 571	Highway Soil Mechanics	DE	3-0-0	3
CEL 436	Computer Aided Analysis and Design	DE	3-0-0	3
CEP 436	Computer Aided Analysis and Design*	DE	0-0-2	1
CEL 531	Spatial Analyses for Resource Management	DE	3-0-0	3
CEP 531	Spatial Analyses for Resource Management*	DE	0-0-2	1
Elective Credits = 03 to 04				
DC + 1 DE = 06 to 07 Credits				

Fourth Semester

Course Code	Course Name	Type DC/DE	Structure	Credits
CED 502	Project Phase - II	DC	-	9
Core Credits = 09				
DC = 09 Credits				

* Student must register both for practical and theory of a course, if theory is not already cleared.

CEL 520 - ADVANCED SOIL MECHANICS (3-0-0); Credits 3]

Course Outcomes:

Student should be able

1. To understand engineering properties of soil through advanced parameters.
2. To understand the effective stress phenomenon in different types of soil.
3. To Stress-strain characteristics of soils, failure mechanism, various factors affecting the shear strength of soil and different test procedures to determine the shear strength.
4. To understand one dimensional and three dimensional consolidation characteristics and secondary consolidation in clays.

Syllabus:

Effective Stress Analysis

Concept of effective stress and its calculation under hydrostatic and hydrodynamic conditions, Capillary fringe condition, Concept of effective stress in partially saturated soils.

Shear Strength

Basic concept, Mohr-Coulomb Theory, measurement of shear strength, drainage conditions along with field problems, Shear strength characteristics of cohesive and cohesionless soil, volume change during shear, dilatancy, critical void ratio, liquefaction, factors affecting shear strength of cohesive and cohesionless soil, Skempton's pore pressure parameters, Hvorslev's shear strength parameters, Stress path, Kf and Ko lines, stress paths for foundation loading; unloading and active; passive cases in retaining walls, sensitivity and thixotropy, Duncan-Chang Model.

Consolidation

Introduction, factors affecting consolidation, measurement of various consolidation characteristic, one way two way drainage, degree of consolidation, Terzaghi's one-dimensional consolidation equation, derivation of three-dimensional consolidation equation in Cartesian and cylindrical co-ordinates, type of clay with role of stress history, determination of pre-consolidation pressure, determination of coefficient of consolidation, field consolidation line for NC and OC clays, secondary consolidation, swell-pressure.

REFERENCES:

1. D. W. Taylor, Fundamentals of Soil Mechanics, Taylor and Francis, Latest.
2. R. F. Scott, Principles of Soil Mechanics, Addison & Wesley, Latest.
3. Gopal Ranjan and A. S. R. Rao, Basic and Applied Soil Mechanics, New Age International Publisher, Latest.
4. B. M. Das, Principles of Geotechnical Engineering, Thomson Publications Company, Latest.
5. V. N. S. Murthy, Soil Mechanics and Foundation Engineering, Alkem Company (S) Pvt. Limited, Latest.

CEL 423 INTRODUCTION TO SOIL DYNAMICS [(3-0-0); Credits 3]

Course Objective:

This course is designed to provide an introduction to dynamics with Soil Dynamics and Geotechnical Earthquake Engineering. The fundamental theoretical and computational aspects of dynamics are developed for important geotechnical problems. The topics include: foundation vibration, dynamic soil structure interaction, construction-induced vibration, seismic ground motion, dynamic response of soil sites, and soil liquefaction.

Syllabus:

Introduction to dynamic loading: Earthquake loading, machine vibrations, blast loading, background and lessons learnt from damages in past earthquakes due to soil and ground failure, effect of soil on seismic response of structures, seismic waves and their characteristics

Dynamic soil properties: Static and dynamic characteristics of soils, stress-strain behaviour of cyclically loaded soils, effect of strain level on the dynamic soil properties, equivalent linear and cyclic nonlinear models, measurement of seismic response of soil at low and high strain, using laboratory tests, cyclic triaxial, cyclic direct simple shear, resonant column, shaking table, centrifuge and using field tests - standard penetration test, plate load test, block vibration test, SASW/MASW tests, cross bore hole

Ground Response Analysis: Introduction to 1, 2 and 3 D ground response analyses, derivation of 1 D ground response analyses, equivalent linear and nonlinear approaches, fundamental period of uniform and layered soil

Soil Amplification: Effects of local soil conditions on ground motion, concept of response spectra, instrumental, experimental and numerical methods to determine soil amplification factors, standard spectral ratio, surface to borehole ratio, H/V ratio for noise and microtremors, Indian response spectra for different soil types IS 1893 Part 1

Soil-Structure Interaction: Introduction to soil-structure interaction, direct and substructure methods of analysis, kinematic interaction, inertial interaction, foundation damping, effect of base slab averaging and embedment, SSI analyses for nonlinear static analyses of structures

Liquefaction: Effects of liquefaction, pore pressure, liquefaction related phenomena – flow liquefaction and cyclic mobility, factors affecting liquefaction, liquefaction of cohesionless soils and sensitive clays, liquefaction susceptibility, evaluation of liquefaction potential, characterization of earthquake loading and liquefaction resistance, cyclic stress ratio, Seed and Idriss method.

Course Outcome:

In this course, the students are expected to learn

1. Basic Theoretical and Computational Dynamics
2. Earthquake and Seismic Hazards
3. Strong Ground Motion Characteristics
4. Design Ground Motion at a Site
5. Dynamic Response Analysis
6. Effect of Local Site Conditions
7. Soil Liquefaction
8. Foundation Vibration Analysis
9. Dynamic Soil Structure Interaction
10. Construction-induced Vibration

REFERENCES:

1. Prakash, S. (1981). Soil dynamics. New York: McGraw-Hill.
2. Kramer, S. L. (1996). Geotechnical earthquake engineering (Vol. 80). Upper Saddle River, NJ: Prentice Hall.
3. Ranjan, G., and Rao, A. S. R. (2007). Basic and applied soil mechanics. New Age International.
4. Kameswara Rao, N. S. V. (2000). Dynamics soil tests and applications.Wheeler Publishing Co. Ltd., New Delhi, India.
5. Robert, W. D. (2002). Geotechnical Earthquake Engineering Handbook. NY: McGraw-Hill

CEL 521 APPLIED SOIL ENGINEERING [(3-0-0); Credits 3]

Course Outcomes:

Student should be able

1. To understand the basic theories and geotechnical design of different types of earth retaining structures.
2. To understand engineering behavior of soils such as arching, soil pressure on conduits.
3. To understand basic concepts in soil engineering for stability analysis of complex geotechnical problems.

Syllabus:

Earth pressure

Earth pressure at rest, Lateral earth pressure, Rankine's earth pressure theory, plastic equilibrium condition in soil: general and local cases, Coulomb's earth pressure theory, Graphical solution of active and passive cases by Poncelet construction, Culmann's graphical solution without and with line load.

Sheet pile, Cofferedam, Braced cuts and Underground conduits

Types, uses and advantages, design of cantilever sheet pile wallin cohesive and cohesionless soil, design of anchored bulkhead using free earth and fixed earth methods, design of anchors

Introduction, advantages, types of cofferdam, Stability analysis of cofferdam

Introduction, types of braced cuts, design of braced cuts

Underground conduits and their classification, ditch conduit, positive projection conduit, negative projection conduit, imperfect ditch conduit, tunnelled conduit, loads on conduits, construction of conduits.

Stability of slopes

Introduction, stability analysis of finite and infinite slopes, Fellenius method, Taylor's stability number, Friction circle method, Culmann's method, Bishop's simplified method, slope stability analysis using design charts, Stability of earthen dam slope under steady seepage and sudden drawdown conditions, Filter types, selection and design criteria, methods for improving stability of slopes.

REFERENCES:

1. Gopal Ranjan and A. S. R. Rao, Basic and Applied Soil Mechanics, New Age International Publisher, Latest.
2. Donald P. Docuto, Geotechnical Engineering, Principles and Practice, Prentice Hall.
3. V. N. S. Murthy, Soil Mechanics and Foundation Engineering, Alkem Company (S) Pvt. Limited, Latest.
4. V. N. S. Murthy Advanced Foundation Engineering, Geotechnical Engineering Series Alkem Company (S) Pvt. Limited, Latest.

CEL 442 GEOTECHNICAL INVESTIGATIONS FOR CONSTRUCTION PROJECTS

[(3-0-0); Credits: 3]

Course Outcomes:

1. To make the students capable of solving real problems related to Geotechnical engineering, once he/she join industries as a fresh geotechnical engineer.
2. In this course all the topics will be taught from the application point of view with examples from case histories and a student will get a chance to apply his theoretical knowledge to solve real geotechnical challenges.
3. Introduction with advance methodology, techniques and tools related to geotechnical investigation

Syllabus:

Introduction, Planning of sub-surface programs, Stages in sub-surface exploration, Reconnaissance, Lateral extent and depth of exploration, Methods of exploration – trial pits, open excavation, boring etc.,
Types of boring and drilling – Auger, wash, rotary, percussion, core etc., Methods for stabilization of borehole, Types of soil samples, Sample disturbance, storage, labelling and transportation of samples
Types of soil samplers – Split spoon sampler, Scraper bucket sampler, Shelby tube and thin wall samplers, piston sampler, Denion sampler, hand carved samples etc.
Field Tests – Standard Penetration Test, Cone Penetration Test, Vane Shear Test, Plate Load Test, Pressure Meter Test
Determination of ground water table
Geophysical methods, Seismic methods, Electrical resistivity methods
Soil investigation report – Borelog, soil profile and contents of report, Field records
Safety measures and Geotechnical risks
Field Instrumentation: Rollers, Pressure meters, Piezometer, Pressure cells, Sensors, Inclinometers, Strain gauges etc.
Site investigation in the view of ground improvement

Geotechnical Engineering Case Histories and Forensic studies: Earthen dam and reservoir, Industrial Structures, Ground Liquefaction, opencast coal mining, landslides, failure of geotechnical structures under critical natural hazards, debris flow, forensic geotechnical investigation, karst topography, Land reclamation, expansive soils, sports field engineering.

REFERENCES:

1. S. K. Saxena, S. A. Gill and R. G. Lukas**,** Subsurface Exploration and Soil Sampling, American Society of Civil Engineers
2. K. R. Arora, Soil Mechanics and Foundation Engineering, Standard Publisher Dist.
3. A. Patel, Geotechnical Investigations and Improvement of Ground Conditions. Elsevier Science.
4. P. Purushothama Raj, Ground Improvement Techniques, Laxmi Publications
5. Indian, British and ASTM Standards on site investigation and field tests
6. Quarterly Journal of Engineering Geology – Relevant articles

CEL 522 GEOMACHANICS **[(3-0-0); Credits: 3]**

Course Outcome:
At the end of the course, the student will be enriched with wealth of information and knowledge on elastic and plastic equilibrium in soils through constitutive relations thereby enabling them to gain confidence on analysis and modeling the behavior of soils interacting with various structural components.

Syllabus:
Review of basic concepts of continuum mechanics: stresses, strains, compatibility conditions, transformation of stresses and strains in rotated co-ordinate system, constitutive relations, stress functions, stress and displacement formulations.

Plane stress and plane strain problems; Theory of plasticity: yield criterion, plastic potential and plastic flow rule, principle of maximum plastic work, strain hardening and perfect plasticity.

Isotropic and kinematic hardening, general stressstrain relations; Perfect plasticity constitutive relations: elastic models, plasticity models for cohesive and frictional soils.

Method of stress characteristics or slip line method: theorem, formulation for stress characteristics, application to different geotechnical structures such as foundation problem, retaining wall problem, slope stability etc.

Limit analysis: lower and upper bound theorem of plastic collapse, lower and upper bound limit analysis, lower and upper bound analysis using linear programming, application to different geotechnical structures such as foundation problem, retaining wall problem, slope stability etc.

REFERENCES:
1. Wai-fai Chen, Limit Analysis and Soil plasticity, Cengage Learning, USA.
2. L S Srinath, Advanced mechanics of Solids, McGraw Hill Education, USA.
3. Bowles J. E. (1996), Foundation Analysis and Design, McGraw Hill Pub. Co., USA.

CEP 504 GEOTECHNICAL ENGINEERING LABORATORY WORK: [(0-0-2); Credit 1]

Course Outcomes:
Student should be able to perform different laboratory investigations on soil.

Syllabus:
1. Collection of Undisturbed / Disturbed Sample for laboratory testing,
2. Hydrometer Analysis
3. Direct Shear Test
4. Tri-axial Tests
5. Unconfined Compressive Strength Test (Soil and Rock)
6. Consolidation Test
7. Swell Pressure Tests.

REFERENCE:

1. Das, B.M., Soil Mechanics Laboratory Manual, Oxford University Press, Sixth Ed.
2. Relevant IS, British and ASTM Standards

CEL 526 GROUND WATER HYDROLOGY [**(3-0-0); Credits 3]**

Course Outcomes:

Student should be able

1. To understand different geological formations.
2. To calculate permeability of different types of soil.
3. To know about salt water intrusion and pollutant transport through soil.

Syllabus:

Introduction:

Occurrence of ground water, geological formations as aquifers; types of aquifers.

Ground Water movement:

Darcy's law, permeability and its measurement, tracing of ground water movement, fundamental equations for steady and unsteady ground water flow, flow nets.

Well hydraulics:

Steady flow in confined, semi-confined and unconfined aquifers, radial flow, superposition; multiple well system. Different methods of well construction; construction of well casings and screens, natural and artificial gravel packed wells. Safe yields, estimation, pumping and recuperation tests. Two dimensional flow, methods of solution, infiltration galleries, Ground-water replenishment, recharge of ground water, different methods.

Salt water intrusion:

Concept; interface and its location; control of intrusion.

Pollutant transport:

Plume Transport, source identification, tracer methods.

REFERENCE:

1. David Reith Todd, Groundwater Hydrology John Wiley publishers 2002.
2. Ragunath H M Groundwater & Well Hydraulics, Wiley Eastern Ltd, New Delhi 2000.
3. Freeze &Chezzy, Groundwater Hydrology John Wiley publishers

CEL 417 DISASTER MANAGEMENT [(3-0-0); Credits 3]

Course Outcomes

1. To introduce the students about the challenges/phases in disaster management.
2. To make students aware about technologies, which can be implemented for solving the problem of disaster management.
3. To make students self-efficient to solve the challenges with the aid of technological aids.

Syllabus:

Introduction to Disasters- Overview, Classifications, causes, loss of resources, Disaster Risk Management-Objectives, Processes, Events, analysis, base-line data, forecasting and warning. Emergency operation centre and IT aids- physical environment, IT Aids, Applications. Techno-legal & Techno-financial aspects-regulatory mechanism for compliance, administrative structure for legal framework, additional cost on infrastructure, building by-laws. Public-private agency co-ordination- federal, state and local disaster response organization and network, citizen and community role in disaster response and recovery. .Case studies: Natural and man-made disasters, preparedness and planning

Reference Books:

1. D B N Murthy, Disaster Management: Text & Case Studies, Deep & Deep Pvt. Ltd., Latest.
2. S L Goel, Encyclopedia of Disaster Management, Deep & Deep Pvt. Ltd., Latest.
3. G K Ghosh, Disaster Management, A P H Publishing Corporation, Latest.
4. Satish Modh, Citizen's Guide to Disaster Management, Macmilan, Latest.

CEL 508 ENVIRONMENTAL GEOTECHNIQUES **[(3-0-0); Credits 3]**

Course Outcomes:

The students are expected to learn about:

1. Geotechnical re-use of waste materials
2. Rehabilitation of old waste dumps
3. Detection and monitoring of subsurface contamination
4. Remediation and control of toxic and hazardous waste sites
5. Planning, designing and construction of landfills using MSW, pond-ash, mine tailings etc.

Syllabus:

Fundamentals of Geoenviromental Engineering:

Scope of geoenvironmental engineering - multiphase behavior of soil – role of soil in geoenvironmental applications – importance of soil physics, soil chemistry, hydrogeology, biological process – sources and type of ground contamination – impact of ground contamination on geoenvironment - case histories on geoenvironmental problems.

Soil-Water-Contaminant Interaction

Soil mineralogy characterization and its significance in determining soil behavior – soil-water interaction and concepts of double layer – forces of interaction between soil particles.

Concepts of unsaturated soil – importance of unsaturated soil in geoenvironmental problems - measurement of soil suction - water retention curves - water flow in saturated and unsaturated zone.

Soil-water-contaminant interactions and its implications – Factors effecting retention and transport of contaminants

Waste Containment System

Evolution of waste containment facilities and disposal practices – Site selection based on environmental impact assessment –different role of soil in waste containment – different components of waste containment system and its stability issues – property evaluation for checking soil suitability for waste containment – design of waste containment facilities

Contaminant Site Remediation

Site characterization – risk assessment of contaminated site - remediation methods for soil and groundwater – selection and planning of remediation methods – some examples of in-situ remediation

Advanced Soil Characterization

Contaminant analysis - water content and permeability measurements – electrical and thermal property evaluation – use of GPR for site evaluation - introduction to geotechnical centrifuge modelling

REFERENCES:

1. Reddi L.N. and Inyang, H. I., "Geoenvironmental Engineering, Principles and Applications" Marcel Dekker Inc. New York, 2000
2. Sharma H.D. and Reddy K.R., "Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies" John Wiley & Sons, Inc., USA, 2004
3. Fredlund D.G. and Rahardjo, H., "Soil Mechanics for Unsaturated Soils" Wiley- Interscience, USA, 1993
4. Ghildyal, B.P. and Tripathi R. P., “Soil Physics”, 2nd Edition, New Age Publishers

MAL 401 FINITE DIFFERENCE METHOD FOR DIFFERENTIAL EQUATIONS

[(3-0-0); Credits 3]

Objective:

The objective of this subject is to expose student to understand the importance of finite difference methods for solving ordinary and partial differential equations.

Syllabus:

Finite difference methods: finite difference approximations for derivatives, boundary value problems with explicit boundary conditions, implicit boundary conditions, Quasilinearization, Cubic splines and their application for solving two point boundary value problems.

Solution of Partial Differential Equations: Classification of partial differential equations, finite difference approximations for partial derivatives and finite difference schemes for:

Parabolic equations: Schmidt's two level, multilevel explicit methods, Crank-Nicolson's method.

Hyperbolic Equations: Explicit methods, implicit methods, one space dimension, two space dimensions.

Elliptic equations: Laplace equation, Poisson equation, iterative schemes.

Computation using MATLAB.

Text Books:

1. G.D. Smith: Numerical solution of Partial Differential equations, Finite Difference methods, Oxford University Press, 1985.
2. M.K. Jain, S.R.K. Iyengar & R.K. Jain: Numerical Methods for Scientific & Engineering Computation, New Age International Publishers, 1996.

Reference Books:

1. DR. Lothar Collatz: The numerical treatment of differential equations, Springer-Verlag, New York 1960.
2. K.W. Morton & D.F. Mayers: Numerical solution of Partial differential equations, Cambridge University press. 2005.
3. M.K. Jain: Numerical solution of Differential equations, Wiley Eastern, New Delhi, 1984.

CEL 523 – ADVANCED FOUNDATION ENGINEERING [(3-0-0); Credits 3]

Course Outcomes:

At the completion of this course, the student shall acquire knowledge and ability - to select and design appropriate foundations based on various criteria; to check the stability of various components of foundations.

Syllabus:

Shallow Foundations

Introduction, Terzaghi's, Meyerhoff, Hansens bearing capacity theories, Types of shear failures, Effect of water table on bearing capacity, layered soils, eccentric and inclined loads, Bearing capacity on slopes, Annular Footings, Rigid and flexible foundations, Foundation settlements, plate load test

Design of Individual, Combined and Raft Foundations for axial and bending loads (Uniaxial and biaxial)

Pile Foundations

Introduction, classification, Load transfer mechanism, Static and dynamic formulas for pile capacity in various soil types, negative skin friction, group action, settlements, pile load test, laterally loaded vertical piles, effect of pile driving

Analysis and design of pile and pile cap

Drilled Piers and Caissons

Introduction, types, Construction of drilled piers, advantages and disadvantages, Design considerations, bearing capacity equations, Settlements, Types of caissons, stability analysis, advantages and disadvantages of caissons

Well Foundation

Different shapes of well, grip length, forces acting on well foundation, Trezaghi's analysis, components of well, sinking of wells, measurement and rectification of tilts and shifts

REFERENCES:

1. N.P. Kurien, Design of Foundation Sytems, Principles & Practices, Narosa,
2. E.S. Melerski, Design Analysis of Beams, Circular Plates and Cylindrical Tanks on Elastic Foundation, Taylor and Francis,
3. L.C. Reese, Single piles and pile groups under lateral loading, Taylor & Francis,
4. V.N.S. Murthy, Advanced Foundation Engineering, CBS Publishers & Distributors,
5. P. C. Varghese, Foundation Design, PHI Learning Pvt. Ltd.,

CEL 575 GROUND IMPROVEMENT TECHNIQUES [(3-0-0); Credits: 3]

Course Outcomes:
Student should be able
1. To understand different issues related to problematic soils and their associated solutions.
2. To learn various ground improvement techniques and their application in field.
3. To propose suitable remedial techniques and design.

Syllabus:
Introduction
Introduction, Classification, Necessity, Concept and essential requirements, economic consideration and suitability

Compaction and consolidation
Theory of compaction, control of field compaction, various shallow compaction techniques, deep compaction techniques (preloading, vibroflaotation, blasting, compaction piles, dynamic compaction), vacuum preloading technique, sand drain, layout, function and application radial consolidation using sand drain with free stain and equal strain cases, strip drains.

Stabilization & grouting
Methods of stabilization, mechanical stabilization, stabilization of soil using cement, lime, bitumen, chemical and fly ash, ground freezing and thermal stabilization.
Methods of grouting, grout materials, requirements of good grout matrial and tests.

Reinforced earth
Introduction to reinforced earth and various geosynthetic materials, functions and applications, soil nailing, ground anchor.

Stone columns
Introduction, layout, function and application, advantages, vibrofloatation and rammed technique of stone column installation, Analysis of stone column treated soft soil, unit cell concept, load transfer mechanism, load carrying capacity and settlement analysis, different methods to improve the effectiveness of stone column, strengthening by micropiles.

Dewatering, Conventional and non-conventional techniques
Methods of dewatering, layout and design consideration
CNS technique to reduce swelling behaviour in expansive soil
Microbial technique, Nano-soil, Nano-fibre, biological treatments

REFERENCES:

1. Foundation Analysis and Design, Bowels, J. E. McGraw-Hill International Edition Singapore, 1997
2. Ground Improvement, Moseley, M. P, Blackie Academic & Professional, BocaRaton, Florida, USA, 1993
3. Foundation Design, Teng, W. C, Prentice-Hall of India Pvt. Ltd.
4. P. Purushothama Raj, Ground Improvement Techniques, Laxmi Publications.
5. A. Patel, Geotechnical Investigations and Improvement of Ground Conditions. Elsevier, 1st Ed., 2019

CEL 581 DESIGN OF UNDERGROUND STRUCTURES [(3-0-0); Credits: 3]

Course Outcomes:

1. To make the students understand engineering properties of rock, classification of rocks.
2. Laboratory testing of rocks, failure criteria, tunneling in rocks.
3. Various techniques to improve the in situ strength of rocks.

Syllabus:

Introduction to tunneling: Fundamental definitions, tunneling art and engineering, historical Development. Geological aspects of tunneling, Rock Mass Classification Systems, Rock load classification according to Terzaghi, RQD index as a qualitative description of the rock mass, limitations and advantages, Lauffer-Pacher classification, Rock structure rating (RSR), Geomechanics Classification: General Comments on Application of Rock Mass Classification Schemes, Comparison of Rock Mass Classification Schemes. Excavation Methodology: Soft ground conditions: Shield Tunnels, Advantages of shield tunneling, Conventional Tunneling Shields, rock conditions using drill and blast: Influence of rock strength on excavation, influence of tunnel size, summary of drilling and blasting method of tunnel excavation drilling blasting debris clearance, ground support drilling and blasting: Ground treatment in tunneling Ground control; general appreciation, weak cohesionless soils: water and instability problems, ground treatment methods, dewatering using well bores electro-osmosis, grouting, ground freezing, investigation procedures, consolidation grouting, compaction grouting, jet grouting. Design and support of tunnels: operational criteria and principal support types: Temporary ground support, constructability, geotechnical design, considerations, common support types used in civil engineering tunnels, mining engineering tunnels, mining legislation, , design methods: analytical methods, computational or numerical methods, empirical methods, rock reinforcement: Rock dowels, rock bolts, rock anchors, mechanisms of support, physical aspects of rock reinforcement. concrete and shotcrete linings, General Concepts of NATM. Stresses and displacements associated with excavation of tunnels: Stresses in the Earth, Effect of Tunnel Formation on the Stress Field, Gravity Loading of Near Surface Tunnels, Non-hydrostatic stresses, Rock Mass Failure and Displacements, Interaction of tunnel stress fields.

REFERENCE:

1. B.H.G. Brady and E.T. Brown, Rock Mechanics for underground mining, Springer
2. D. Kolymbos, Tunnelling and Tunnel Mechanics, Springer
3. Bhawani Singh and R.K. Goel, Rock Mass Classification, Elsevier
4. Z. T. Bieniawski, A.A. Balkema, Rock mechanics design in mining and tunneling
5. Evert Hoek, Edwin T. Brown., Underground Excavations in Rock, Institution of Mining and Metallurgy

CEP 505 GEOTECHNICAL ENGINEERING FIELD WORK: [**(0-0-2); Credit 1]**

Course Outcomes:
Student should be able to perform Geotechnical filed investigations for different projects.

Syllabus:
1. Field identification of soils & rocks
2. Collection of Disturbed / Undisturbed samples
3. Standard Penetration Test
4. Plate Load Test
5. Pressure-meter Test
6. Ground water measurement
7. Field Vane Shear Test
8. Geophysical Investigation

REFERENCE:

1. V.N.S. Murthy, Advanced Foundation Engineering, CBS Publishers & Distributors
2. A. Patel, Geotechnical Investigations and Improvement of Ground Conditions. Elsevier, 1st Ed., 2019
3. Relevant IS, British and ASTM Standards

CEP 506 GEOTECHNICAL SYSTEM DESIGN [**(0-0-2); Credit 1]**

Course Outcomes:
Student should be able to design different geotechnical components of civil structures..

Syllabus:

Any one of the followings by individual student

1. Design of shallow foundation system
2. Design of deep foundation system
3. Design of reinforced earth wall / retaining wall
4. Design of machine foundation
5. Design of sand drain / strip drain layout
6. Design of stone column layout

AML 548 SOIL-STRUCTURE INTERACTION **[(3-0-0); Credits 3]**

Course Outcomes:

At the completion of this course, the student shall acquire knowledge and ability,

1. to understand the behavior of structure with soil-structure interaction.
2. to analyse beams on wrinkle foundation and model soil-structure interaction analysis problem.

Syllabus:

General soil-structure interaction problems: Contact pressures and soil-structure interaction for shallow foundations. Concept of sub-grade modulus, effects/parameters influencing subgrade modulus. Analysis of foundations of finite rigidity, Beams on elastic foundation concept, introduction to the solution of beam problems.

Analytical Methods of Analysis of Finite Beams on Wrinkler Foundation: Introduction, analysis of finite and infinite beam on wrinkle foundation, method of super position, method of initial parameters and its application to analysis of regular beams, analysis of continuous beams and frames on wrinkle foundation, analysis of frames on wrinkle foundation, analysis of rigid piles with horizontal and vertical loads.

Analysis of Beams on Elastic Half Space: Introduction, analysis of Rigid Beams, short beam analysis, long beam Analysis, Analysis of Frame on Elastic Half Space.

Dynamic Soil Structure Interaction: Direct and Sub-structure method of Analysis, Equation of Motion for flexible and rigid base, kinematic interaction, inertial interaction and effect of embedment, Temporal and special variation of external loads including seismic loads, continuous models, discrete models and finite element models.

Wave Propagation for SSI: Waves in Semi-Infinite Medium, one two and three-dimensional wave propagation, dynamic stiffness matrix for out of plane and in plane motion.

Free Field Response of Site: Control point and control motion for seismic analysis, dispersion and attenuation of waves, half space, single layer on half space, modelling of boundaries, elementary, local, consistent and transmitting boundaries.

Engineering Application of Soil-Structure Interaction: Low rise residential building, multi-storey building, bridges and dams, soil-pile structure interaction.

REFERENCES:

1. Tsudik, E. (2012). Analysis of Structures on Elastic Foundations. J. Ross Publishing
2. Wolf, J. P. (1985). *Dynamic soil-structure interaction*. Prentice Hall int.
3. Wolf, J. P., & Song, C. (1996). *Finite-element modelling of unbounded media*. Chichester: Wiley.
4. Kramer, S. L. (1996). *Geotechnical earthquake engineering* (Vol. 80). Upper Saddle River, NJ:
1. Prentice Hall.
5. Kellezi, L. (1998). Dynamic Soil-Structure-Interaction
6. Jones, G. (1997). Analysis of beams on elastic foundations: using finite difference theory. Thomas Telford.

AML 549 FINITE ELEMENT METHOD **[(3-0-0); Credits 3]**

Course Outcome

At the completion of this course, the student shall acquire knowledge and ability,

1. to develop comprehensive knowledge in the fundamental of basis of FEM,
2. to build FEM models of physical problems and apply appropriate constraints and boundary conditions along with external loads.
3. to use professional-level finite element software to solve engineering problems.

Syllabus:

Introduction to Finite element method, History, Applications, Introduction to Rayleigh Ritz Method, Stress strain relationship, strain displacement relationship, Equilibrium equations (Total potential approach, Virtual work approach)

Shape function, Stiffness matrix, Formulation of 1-D elements (BAR, TORSION, BEAM), 2D elements and 3D elements, load vector (1D, Plane stress, Plane strain, Axi-symmetric and 3D elements) using Displacement formulation. Cartesian and Iso-parametric element formulation.

Numerical Integration, convergence study, element with drilling DoF and incompatible modes.

Plate elements (Kirchoff theory, Mindlin plate element, triangular and rectangular, conforming & nonconforming elements),

Shell elements (flat faced triangular and rectangular elements), Axisymmetric plate & shell elements, Ring elements. Introduction to advanced elements-Mixed formulation, Infinite elements.

Formulation for Geometrical Nonlinear problems. Formulation of Dynamic problems, Consistent and lumped mass matrices.

Computer Implementation of FEM procedure for plane truss, Plane stress, plane strain and Axisymmetric problems. Mathematical modeling of structures.

Constraint Equations (Penalty method, Lagrangian method), Patch test

REFERENCES:

1. Dhatt, G., Lefrançois, E., &Touzot, G. (2012). *Finite element method*. John Wiley & Sons
2. Bathe, K. J. (2008). *Finite element method*. John Wiley & Sons, Inc.
3. Zienkiewicz, O. C., Taylor, R. L., Zienkiewicz, O. C., & Taylor, R. L. (1977).*The finite element*
4. *method* (Vol. 3). London: McGraw-hill.
5. Hughes, T. J. (2012). The finite element method: linear static and dynamic finite element analysis.
6. Courier Corporation.
7. Reddy, J. N. (1993). *An introduction to the finite element method* (Vol. 2, No. 2.2). New York:
8. McGraw-Hill.
9. Cook, R. D. (2007). Concepts and applications of finite element analysis. John Wiley & Sons.
10. Cook, R. D. (1994). Finite element modeling for stress analysis. Wiley.
11. Chandrupatla, T. R., Belegundu, A. D., Ramesh, T., & Ray, C. (1997).*Introduction to finite*
12. *elements in engineering* (pp. 279-300). Upper Saddle River: Prentice Hall.
13. Strang, G., & Fix, G. J. (1973). *An analysis of the finite element method* (Vol. 212). Englewood
14. Cliffs, NJ: Prentice-Hall
15. Prathap, G. (2013). The finite element method in structural mechanics: principles and practice of
16. design of field-consistent elements for structural and solid mechanics (Vol. 24). Springer Science &
17. Business Media.
18. Rao, S. S. (2005). *The finite element method in engineering*. Butterworth-heinemann

MNL 525 BLASTING TECHNOLOGY IN EXCAVATIONS [(3-0-0); Credits 3]

Course Outcome

1. To provide advance knowledge of blasting
2. To develop designing capability for blasting in excavation

Syllabus:

Chemistry and physics of explosives; properties of explosives

Explosives and blasting agents; initiation and priming systems bulk explosives; explosive selection

Rock breakage by explosives theories, laws of comminution, methods for prediction and assessment of fragmentation;

Design of blasting rounds for surface and underground excavation, special blasting techniques including secondary breakage, pre-splitting, destress blast technique, Lake tap design

Profiling, trenching, casting and demolition, environments considerations, handling and storage of explosives control of noise, vibration, air blast and fly rock

Blasting optimization, intelligent blast design, blast economics, computer applications in blasting

REFERENCES:

1. Dr. Calvin Konya, Rock Blasting and Overbreak Control
2. Stig o Olofsson, Applied explosive technology for construction and mining, APPLEX P O Box 71 S-640 43 ÄRLA SWEDEN

MNP 525 BLASTING TECHNOLOGY IN EXCAVATIONS [(0-0-2); Credits 1]

Syllabus:
Lab experiments and field visits will be conducted based on topics from the course MNL 525

CEL 441 GEOTECHNICAL ASPECTS FOR DESIGN OF MACHINE FOUNDATION

[(3-1-0); Credits 4]

Course Outcomes:

1. Introduction to vibration of a system.
2. Concept of different mode of vibration.
3. Physical significance of wave propagation theory.
4. Relevant soil parameters and Instrumentation.

Syllabus:

Introduction: Vibration of elementary systems-vibratory motion-single degree freedom system-free and forced vibration with and without damping.

Mode of vibration: Basic theory of vibrations-free and forced vibration of single degree of freedom with and without damping-two degrees of freedom with and without damping-dynamic soil properties-mass spring model and constants- elastic half space approach-determination of dynamic soil constants in laboratory and field based on IS code provisions. Modes of vibration of block foundation – natural frequency of foundation of soil system by Barkan's approach-methods of analysis-Barkan's method. Vertical translations, sliding, rocking, yawing (IS code method).

Concept of waves and wave propagation: Wave propagation in an elastic homogeneous isotropic medium-Raleigh, shear and compression waves in elastic half space.

Dynamic properties of soils: Elastic properties of soils-coefficient of elastic, uniform and non-uniform compression – shear effect of vibration dissipative properties of soils-determination of dynamic properties of soil codal provisions.

Design procedures: Design criteria -dynamic loads - simple design procedures for foundations under reciprocating machines – machines producing impact loads - rotary type machines with Code Provision.

Vibration isolation technique: Vibration isolation technique-mechanical isolation-foundation isolation-isolation by location isolation by barriers- active passive isolation tests.

Tutorial:

1. Determination of degree of freedom for different systems.Single degree freedom system-free and forced vibration with and without damping, determination of natural frequency, damping ratio etc.
2. Determination of natural frequency of foundation- soil system by Barkan's approach and IS code method (IS 2974-PART 1, 2, 3 and 4).
3. Determination of dynamic properties of soil for real sites, numerical.
4. Simple design procedures for foundations under reciprocating machines, using IS Code provisions. A complete design problem will be practiced.

REFERENCES:

1. Bhatia, K.G. (2008). "Foundations for Industrial Machines—A Handbook for Practising Engineers",D-CAD Publishers, New Delhi.
2. Kameswara Rao, "Dynamics Soil Tests and Applications", Wheeler Publishing, New Delhi
3. Saran Swami, "Soil Dynamics and Machine Foundation", Galgotia Publication
4. Barkan, D.D. (1962). "Dynamics of Bases and Foundations", McGraw-Hill Book Company, NewYork, U.S.A.
5. Kramar S.L, "Geotechnical Earthquake Engineering", Prentice Hall International series, Pearson Education (Singapore) Pvt. Ltd 54

CEL 510 ENVIRONMENTAL MANAGEMENT **[(3-0-0); Credits 3]**

Course Outcome:

1. Understand the environmental, social and economic framework in which environmental management decisions are made understand the life cycle perspective, systems approach and environmental technologies for converting process, products and service related industrial environmental problems into opportunities to improve performance
2. Anticipate, recognize, evaluate, and control environmental issues in a variety of sectors and industries and liaison with federal, state, and local agencies and officials on issues pertaining to environmental protection
3. Recognize, evaluate, and control factors in the workplace and the environment that cause health and environmental hazards and utilize quantitative knowledge and skills and modern tools and technologies to assess, analyze, plan, and implement environmental management systems
4. Obtain, update, and maintain plans, permits, and standard operating procedures.
5. Prepare, review, and update environmental monitoring and assessment Report sand Monitor progress of environmental improvement programs

Syllabus:

Sustainable development and strategies, Waste minimization and pollution prevention strategies – cleaner technologies, Tools of corporate environmental management; Environmental policy, Environmental management systems; ISO : 14000; Environmental Impact assessment, Indian environmental legislations and environmental acts such as Water Act (1974), Air Act (1981), Environmental (Protection) Act (1986); International Environmental Treaties; Life cycle assessment; environmental labeling, environmental audit, Environmental performance assessment; regulatory standards for industrial wastewaters and atmospheric emission.

REFERENCE:

1. Richard Welford, Corporate Environmental Management Systems and Strategies, Universities Press (I) Ltd., Hyderabad, 1996.
2. Paul L. Bishop, Pollution Prevention: Fundamental and Practice, McGraw Hill, International, 2000. Freeman, H.M., Industrial Pollution Prevention Handbook, McGraw Hills 1995

CEL 525 EARTHEN DAMS **[(3-1-0); Credits 4]**

Course Outcomes:

Student should be able

1. To analyze and design rock and soil slopes.
2. To analyze and estimation of seepage quantity.
3. To design different components of earthen dams.

Syllabus:

Introduction: Purpose, types, Advantages of earth dams. General Design Consideration: Field & Laboratory Investigations, Basic Requirement, Selection of embankment Type, Slope Stability aspects, Codal provisions; Earthquake effects. Seepage analysis and control: Types of flow; Laplace equation; Flow net in isotropic, anisotropic and layered media; Entrance-exit conditions; Theoretical solutions; Determination of phreatic line. Embankment Design: Introduction; Factors influencing design; Design of Different components; Stability Analysis, Sheet pile. General Construction Consideration: Foundation preparation, Quality check, Stage construction, necessary Diversion, Compaction control, Record and report Instrumentation - piezometer, settlement gauge, inclinometer; Road and rail embankments. Finishing work for stabilisation: Landslides: Remedial measures for unstable slopes - soil nailing, gabions, drainage, Plantation.

REFERENCE:

1. Christian Kutzner, Earth & Rock fill dams- Principles of design and construction, Published Oxford and IBH., Latest
2. Creager, Justine, Hinds, Engineering for Dams, John Wiley & Sons, Latest.
3. Earth and Earth-rock Dam. W.P. Creager, J.D. Justin and J. Hinds, Engineering for Dams, John Wiley, 1945.

CEL 524 GEOSYNTHETICS [**(3-0-0); Credits 3]**

Course Outcomes:
Student should be able
1. To identify different geosynthetics materials and their applications.
2. To determine various properties of geosynthetics materials.
3. Design of various structures using geosynthetics.

Syllabus:
Introduction
Overview of geosynthetics, development of geosynthetics, products, functions and applications, advantages and beneficial effects.

Geotextile
Properties and test methods, Functions and Applications
Designing for reinforcement, separation, filtration, drainage and stabilization
Design of reinforced earth wall

Geogrid
Properties and test methods, Functions and Applications
Design for bearing capacity

Geomembrane
Properties and test methods, Functions and Applications
Design of landfill liner using geomembrane

Geonet
Properties and test methods, Functions and Applications
Design for drainage

Geocomposites, Geocell, Geofoam, Gabion wall
Introduction, Advantages and Applications

REFERENCE:
1. R. M. Koerner, Designing with Geosynthetics (Vol. 1 & 2), Prentice Hall edition, New Jersey.
2. G. L. S. Babu, An Introduction to Soil Reinforcement & Geosynthetics, Orient Blackswan.
3. J. N. Mandal, Geosynthetics Engineering: In Theory and Practice, Research Publishing, Singapore.

CEL 529 ENGINEERING SEISMOLOGY AND SITE CHARACTERIZATION

[**(3-0-0); Credits 3]**

Course Outcomes:

At the completion of this course, the student shall acquire knowledge and ability - to select and design appropriate foundations based on various criteria; to check the stability of various components of foundations.

Syllabus:

Introduction to earthquake hazards; strong ground motions and site effects; landslides; liquefaction and tsunami damages

Early Engineering seismology and understanding of earthquakes; Introduction to engineering seismology; Terminologies and definitions; Earthquake types, World great Earthquakes, Large and Damaging Earthquakes of India

Overview of plate tectonics; Earthquake source mechanisms; Source models; Types of faults; Activity and fault studies; Concepts of seismic magnitudes and intensity, earthquake size, different magnitude scales and relations; Theory of wave propagation; Seismic waves, body and surface waves.

Earthquake recording instrumentations; Concept of seismograph, Seismic station: Sensors and data loggers; Mechanical and digital sensors; Interpretation of Seismic Records - acceleration, velocity and displacement; Frequency and Time Domain parameters: Response Spectra and Spectral parameters; Epicenter and magnitude determination

Introduction to Site characterization; Different methods and experiments; Geotechnical properties; Site classification and worldwide code recommendation; Concept of site response; Local site effects and evaluation methods; Ground motion amplifications and estimation; Development of response /design spectrum

REFERENCES:

1. Bozorgnia, Y. and Bertero, V.V., Earthquake Engineering – From Engineering Seismology to Performance - Based Engineering, Edited by CRC Press Washington 2004.
2. Earthquake hazard Analysis - Issues and Insights by Leon Reiter, Columbia University Press New York 1990
3. An-Bin Huang and Paul W Mayne, Geotechnical and Geophysical Site Characterization, CRC Press, 2008, ISBN 0415469368.

CEL 532 DESIGN OF EXPERIMENTS [(3-0-0); Credits: 3]

Course Outcome:

Students will be able to design experiments, analyze and optimize the data using various statistical methods.

Introduction Strategy of Experimentation, Some Typical Applications of Experimental Design, Basic Principles, Guidelines for Designing Experiments

Experiments with a Single Factor: The Analysis of Variance(ANOVA),The Analysis of Variance, Analysis of the Fixed Effects Model, Decomposition of the Total Sum of Squares Statistical Analysis, Estimation of the Model Parameters, Unbalanced Data, Model Adequacy Checking, Determining Sample Size, The Random Effects Model, A Single Random Factor, Analysis of Variance for the Random Model, The Regression Approach to the Analysis of, Least Squares Estimation of the Model Parameters, The General Regression Significance Test.

Experimental designs: Randomized complete block design (RCBD), experimental designs: Variants of RCBD such as Latin Square, central composite design, etc. Experimental designs: Full factorial experiments Experimental designs: 2k factorial experiments, Experimental designs: Fractional factorial experiments, Experimental designs: 2k-p factorial experiments, Response surface methodology (RSM)

Laboratory quality control: **Standard control chart concepts: X-bar and range charts,** Shewhart Chart,

Limit of detection: **approach to estimating the MDL, a**nalyzing censored data,

REFERRENCES:

1. M.R. Speigel, Probability and Statistics, McGraw Hill
2. D. C. Montgomery “Design and Analysis of Experiments”, John-Wiley-India

Pre-requisite: Basic statistics

CEL 409 QUALITY AND SAFETY IN CONSTRUCTION [(3-0-0); Credits 3]

Course Outcomes

1. To introduce the students about quality and safety related challenges in construction industry
2. To make students aware about the globally recognized guidelines/theories for quality and safety in construction
3. To make students self-efficient to audit quality and safety related challenges in construction.

Syllabus:

Total quality Management (TQM) to the construction industry: Evolution, philosophy and principles for building client, the Deming Philip Crosby, J. M. Juran contribution to TQM. Quality as a management process, contractual options and integration. TQM to Construction Projects: General application, TQM in pre-contract, post contract, commissioning and maintenance phase, Project quality management, Auditing: First party auditing, second party auditing, Contraction management adjudication. Accidents: types, causes, direct and indirect cost of accidents, objective of accident prevention programmes. Preventative measures: personal protective equipments, job requirements, tools, equipments and fire protection measures. Projection from radioactive/ toxic material, laser and X-ray equipments. Safety Organization and Management: Safety policies, safety organization, safety committees, safety representatives, outside agencies – Govt. intervention, international agreements

REFERRENCE:

1. Ron Baden Hellard, Total Quality in Construction Projects, Thomas Telford, London, Latest.
2. Michael T Kubal, Engineering Quality in Construction, Mc Graw Hill Inc., Latest.
3. Charles D Reese & James V Eidson, Handbook of OSHA Construction Safety & Health, CRC Press, 1999, Latest.

CEL 571 HIGHWAY SOIL MECHANICS [**(3-0-0); Credits: 3]**

Course Outcomes:

Student will be able to estimate earth pressure using different theories and having preliminary knowledge of rock mechanics.

Syllabus:

Classification of Soil. HRB classification. Group Index Method.

Subsoil drainage in Highway Engineering, Design of filters, perforated pipe drainage, Methods of sub soil drainage for roads, permeable blankets, longitudinal and transverse under drains, horizontal drains, stabilizing trenches. Sub soil drainage in highways, runways and railways.

Compaction: Mechanics of compaction. Field-compaction equipment; their suitability and choice. Compaction quality control and measurement.

Shear Strength: Terzaghi's effective stress principle, effective shear parameters, measurement of pore pressures. Stability Analysis of slopes: Friction circle method, Taylor's Stability No.

Earth Pressure Theories: Coloumb's Wedge Theory, Culman's method. Sheet pile walls and their analysis.
Deep foundations: Meyorhoff's theory for bearing Capacity. Well foundations, their types, components, well sinking and rectification. Stability analysis.

Rock Engineering: Fundamental of rock Mechanics; Rock Properties; Rock Mass Classification Systems, Rock load classification according to Terzaghi, RQD index as a qualitative description of the rock mass, limitations and advantages, Geomechanics Classification: General Comments on Application of Rock Mass Classification Schemes, Comparison of Rock Mass Classification Schemes.

Practicals: Experiments and design exercises based on above syllabus and also from courses of other subjects where provision of practical is not available

REFERENCE:

1. Soil Mechanics in Highway Engineering, Rodriguez,A,R, Castillo del.h, Trans Tech Publications
2. Essentials of Soil Mechanics and Foundations, David McCarthy,Pearson Education
3. Basic Soil Mechanics, R. Whitlow, Pearson Education

Relevant IS and IRC codes

CEL 436 COMPUTER AIDED ANALYSIS AND DESIGN [(3-0-0); Credits 3]

Course Outcomes:

1. Knowledge of application tool for civil engineering.
2. Application of techniques and programming aids and implementation in civil engineering problem solving.
3. Students should be able to solve the challenges with the aid of technological aids.

Syllabus:

Introduction to CAAD, physical and mathematical modelling, numerical simulation, introduction to numerical methods, matrix analysis.

Basic of Analytical tools, introduction and application of Finite Element Method, basic idea, features.

Introduction to spreadsheet programming, programming in MATLAB, Basics of Computer Aided Drafting using AutoCAD.

Computer Application in Civil Engineering.

REFERENCE:

1. Reddy J. N., An Introduction to the Finite Element Method, Tata McGraw-Hill Publishing Company Limited.
2. Duggal Vijay, CAAD primer, a general guide to computer aided design and drafting
3. Pratap Rudra, Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers
4. Cook, R. D. (2007). Concepts and applications of finite element analysis. John Wiley & Sons.
5. Wang, C. K., Matrix methods of structural analysis: International Textbook Company 1970.

CEP 436 COMPUTER AIDED ANALYSIS AND DESIGN [(0-0-2); Credits 1]

Syllabus:
10 lab experiments will be conducted based on topics from the course CEL 436

REFERENCE:

1. Reddy J. N., An Introduction to the Finite Element Method, Tata McGraw-Hill Publishing Company Limited.
2. Duggal Vijay, CAAD primer, a general guide to computer aided design and drafting
3. Pratap Rudra, Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers
4. Cook, R. D. (2007). Concepts and applications of finite element analysis. John Wiley & Sons.
5. Wang, C. K., Matrix methods of structural analysis: International Textbook Company 1970.

CEL 531 SPATIAL ANALYSES FOR RESOURCE MANAGEMENT [(3-0-0); Credits 3]

Course Outcomes:

Student should be able

1. To understand fundamentals of data analysis.
2. To evaluate different management systems.

Syllabus:

Fundamentals of Geoinformatics: raster and Vector Data, Resolutions of RS data, Thermal and Radar Sensing, spatial and non spatial information, attribute data collection, data formats, data conversions. RS as a technology for data extraction technique, multithematic data extraction using multispectral sensors, thematic map generation.Overlay analyses, Buffer analyses, Query shell. Spatial analysis, Modeling of spatial data, Network analysis, digital terrain elevation models, Customization and Decision Support Systems. Applications of Geoinformatics for spatial management of resources: Run-off estimations, infiltration characteristics, groundwater potential and recharge characteristics, Watershed management, watershed prioritization, Sediment yield estimation, reservoir capacity studies, Spatial analyses for Environment Impact assessment, Monitoring and feedback, Natural indices, Concept of E-Governance using Geoinformatics. Integrated applications using various technologies within Geoinformatics; methods and approach. Real time and temporal analysis using Geoinformatics. Multidisciplinary applications of Geoinformatics; integration of various segments. Geoinformatics for resources management and utilities management.

REFERENCE:

1. C.P LO Albert KW Yeung, Concepts and techniqes of Geographic Infromation Systems, Prentice Hall of India, 2002
2. C.S. Agrawal & P K Garg,Text Book on Remote Sensing,Wheeler, First
3. Keith C. Clerk, Bradely O Parks, Michel P Crane, Geographic Informaiton System and Enviornment Modeling, Prentice Hall of India , 2002
4. John R Jensen, Remote Sensing of the Environment ..an Earth Resource Perspective Pearson Education, 2006

CEP 531 SPATIAL ANALYSES FOR RESOURCE MANAGEMENT [(0-0-2); Credits 1]

Course Outcomes:
Student should be able to handle different data analysis with computer applications.

Syllabus:
Spatial Digital Data and its Formats, Digital Image analysis and Classification, Vector Data generation, topology building and attribution, Overlay, Buffer and Network analysis, Models for Resource analysis

REFERENCE:

1. C.P LO Albert KW Yeung, Concepts and techniqes of Geographic Infromation Systems, Prentice Hall of India, 2002
2. C.S. Agrawal & P K Garg,Text Book on Remote Sensing,Wheeler, First
3. Keith C. Clerk, Bradely O Parks, Michel P Crane, Geographic Informaiton System and Enviornment Modeling, Prentice Hall of India, 2002

John R Jensen, Remote Sensing of the Environment and Earth Resource Perspective Pearson Education, 2006